Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences
Maritimes Region
Canadian Science Advisory Secretariat
Science Response 2012/014

STATUS OF ATLANTIC SALMON IN SALMON FISHING AREAS (SFAs) 19-21 and 23

Context

Atlantic salmon populations of the Maritimes Region have experienced two or more decades of decline. Atlantic salmon commercial fisheries were closed by 1985. In-river closures of recreational fisheries began in 1990 in the inner Bay of Fundy and expanded to all outer Bay (Salmon Fishing Area, SFA 23) and many eastern and southern shore rivers (SFAs 20 and 21) by 1998. In addition, Aboriginal communities have either reduced or curtailed their fishing activity. There are thought to be four large groupings of salmon in the Maritimes Region: the outer Bay of Fundy (western part of SFA 23), the Nova Scotia Southern Upland (SFAs 20 and 21), the inner Bay of Fundy (SFA 22 and part of SFA 23), and eastern Cape Breton (SFA 19) areas. Many populations are extirpated, and inner Bay of Fundy salmon (SFA 22 and a portion of SFA 23) are listed as Endangered under the Species at Risk Act. In November 2010, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the outer Bay of Fundy, Nova Scotia Southern Upland, and Eastern Cape Breton populations as Endangered.

Science advice on the status of salmon in SFAs 19-21 and 23 was requested by Fisheries and Aquaculture Management (FAM) on 22 December 2011, with a response required by the end of February 2012. This advice is used to inform Aboriginal groups, and the provinces of Nova Scotia and New Brunswick, of the status of the salmon resource in advance of developing harvest agreements and to develop recreational fishing plans for 2012. Given that this request was for an update of previous advice using established methods (e.g., DFO 2011), it was decided to use the Science Special Response Process. This Science Response report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Maritimes Regional Science Special Response Process (SSRP) of February 21, 2012 on the Assessment of Atlantic Salmon.

Overall, the information presented in this report does not outline a positive view of the status of Atlantic salmon in the eastern Cape Breton, Southern Upland, or outer Bay of Fundy areas. Only one of the three index rivers in SFA 19 (North River) met its conservation egg requirement in 2011. None of the other index rivers in SFAs 20, 21, or 23 met their conservation egg requirements in 2011.

Analyses and Responses

Methods

Conservation Requirement

Evaluation of the status of Atlantic salmon in the Maritime Provinces is based on a comparison of predicted egg deposition, which is calculated from the estimated abundance and biological composition of salmon, relative to a reference point known as the conservation egg

requirement. The river-specific conservation egg requirement is based on an egg deposition of 2.4 eggs/m^2 multiplied by the amount of fluvial (of suitable gradient) habitat. The conservation egg requirement was originally adopted by the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) as the level below which CAFSAC would strongly advise that no fishing should occur. This value incorporated uncertainty in management regimes by allowing for a 25% loss of adult salmon between entering the river (returns) and spawning (escapement) (Elson 1975). CAFSAC considered that the possibility of irreversible damage to the stock increased the further spawning escapement was, and the longer it remained, below the conservation egg requirement, even at levels only slightly below (CAFSAC 1991). An egg deposition of 2.4 eggs/m^2 is considered to be a limit reference point (LRP) in the context of DFO's Precautionary Approach framework (DFO 2009).

Angling Mortality

Catch-and-release angling has become more common for salmon management and conservation due to the widespread decline in salmon abundance in the North Atlantic. For populations that are below target levels, catch-and-release angling provides an intermediate management alternative between closing recreational fisheries and allowing retention fisheries. Catch-and-release angling has been practiced in some areas of Canada and the USA since 1984, and both regulated and voluntary catch-and-release angling has been practiced in many European countries in recent years (ICES 2010).

The International Council for the Exploration of the Sea (ICES) evaluated the results of studies that estimate the levels of pre-spawning mortality of salmon caught and released by anglers and their implications for stock assessments (ICES 2009). In most areas of North America, mortality resulting from catch-and-release angling is incorporated into assessments of spawning escapement and returns (ICES 2010). Highly variable rates of fish mortality associated with a fish being hooked and subsequently released have been reported (Dempson et al. 2002; Thorstad et al. 2003). Water temperature is cited as an important factor; angling at low temperatures (i.e., below 17-18°C) generally results in lower mortalities than catch-and-release angling that occurs at higher water temperatures (ICES 2009). ICES (2009) summarized catch-and-release mortality studies on Atlantic salmon, including mortality rates and respective water temperatures. The mortality rates associated with catch-and-release angling at water temperatures less than 12°C are predominately $\leq$3%, and five of five studies conducted at temperatures less than 10°C reported no mortality associated with catch-and release. Although there is information available on the short-term physiological effects of angling (Tufts et al. 2000), there is little information available about other potential effects of catch and release salmon fishing (e.g., potential effects on migration, reproduction, habitat impacts, transfer of pathogens, etc.). An assumption of a 4% catch-and-release mortality is applied to rivers assessed in eastern Cape Breton.

Eastern Cape Breton (SFA 19)

Salmon population monitoring by DFO in eastern Cape Breton is currently focused on three river systems: **Middle, Baddeck, and North** rivers (Appendix 1). Grand River was assessed annually in the past, but this assessment has been discontinued because neither fish counts nor recreational catch data are available for this river. Dive survey counts in the North Aspy River were conducted in 2011, but there is low confidence in the results due to high water levels and characteristics of this river, including poor visibility, that lead to high variability in salmon observation rates. Parks Canada monitors adult salmon abundance on the Clyburn River using similar dive surveys.

Prior to 1998, recreational fishing was open from June 1st to October 31st in eastern Cape Breton. Since 1998, with the exception of the North River, there was a mid-season warm water closure from July 16th – August 31st. In 2010 and 2011, all rivers within SFA 19 with the exception of Middle, Baddeck, North, and North Aspy rivers were closed to fishing all year. In 2011, Middle and Baddeck rivers were open to catch-and-release angling from October 1st to October 31st; North River (downstream from the area known as the "Benches") was open to catch-and-release angling from June 1st to October 31st; and North Aspy River was open to catch-and-release angling from June 1st to July 15th and from September 1st to October 31st (Appendix 2, Table 1). In 2011, approximately 96% of the annual recreational fishing effort within eastern Cape Breton took place on the Middle, Baddeck, and North rivers (Appendix 4).

Table1. Angling season and assessment methods per index river; as well as broodstock program releases, collections, and percentage of conservation egg requirement in the Middle and the Baddeck rivers (SFA 19). Note: NA=not applicable.

	MIDDLE RIVER	BADDECK RIVER	NORTH RIVER	NORTH ASPY RIVER
Angling Season	October 1- 31	October 1- 31	June 1 - October 31	June 1 - July 15 September 1 - October 31
Assessment Information	• Recreational Catch Estimates (License Stub Returns) • Dive Counts • Intermittent Electrofishing Data	• Recreational Catch Estimates (License Stub Returns) • Dive Counts • Intermittent Electrofishing Data	• Recreational Catch Estimates (License Stub Returns) • Dive Counts	• Recreational Catch Estimates (License Stub Returns) • Dive Counts
% Conservation	60% or 64% (with new pools)	84%	Above CSR	NA
Broodstock: releases (+) and collections (-)	+ 12,600 fry (July) + 10,400 (October) + 14 salmon - 1 small and 7 large salmon	+ 6,000 fry (July) + 10,700 (October) + 2 salmon - 1 small and 7 large salmon	NA	NA

Status

Data available for assessing the status of salmon in **Middle River** include annual recreational catch estimates from license stub returns, counts of adult salmon made during dive surveys, as well as intermittent electrofishing data (Table 1). The conservation egg requirement for Middle River is 2.07 million eggs, calculated based on an estimated 864,600 m^2 of habitat and a target egg deposition density of 2.4 eggs/m^2. This egg deposition is expected from about 470 large and 80 small salmon (O'Connell et al. 1997).

Data from the recreational fishery have been collected from salmon license stub returns since 1983, with large salmon (63 cm or larger) and small salmon (less than 63 cm) being recorded separately. The data include the number of salmon caught and released, the number harvested, and fishing effort in each year. Effort is estimated in rod days where any portion of a day fished by one angler is recorded as one rod day. Values are adjusted for non-returned stubs using a relationship based on the reported catch as a function of the number of reminder letters sent to licensed anglers. The preliminary estimates of the recreational catch in 2011 were 172 small (including 3 retained) and 179 large salmon with an estimated effort of 646 rod days (Appendix 4). Although the effort was 12% lower in 2011 compared to 2010, the total catch was 21% higher in 2011 compared to 2010, with more small salmon (e.g., 172 versus 72) and less

large salmon (e.g., 179 versus 217) caught in 2011 compared to 2010. Analysis of the recreational fishing data series indicates that fishing effort on this river has shown an increasing trend over the last ten years.

In 2011, one small male salmon, three large male salmon, and four large female salmon were removed from the population by the province of Nova Scotia for use as broodstock in a stocking program. The stocking program was designed to offset anticipated future losses to the population from catch-and-release mortality. A total of 12,600 fry resulting from last year's broodstock collection were released into Middle River on July 20, 2011, and an additional 10,400 fin clipped age-0 fall parr were released on October 17, 2011, as part of this program. In addition, parr were collected from a provincial stocking program, grown to adults by DFO, and the first release of 14 adults was in 2011 with an aim to support Food, Social, and Ceremonial use.

The numbers of large and small salmon counted during dive surveys in Middle River from 1989 to 2011 provide indices of spawning escapement for this population. These surveys typically take place during the last week of October, just prior to the end of the fishing season. During the dive survey (Oct. 24, 2011) 110 small and 235 large salmon were counted in total but 47 of them (28 large and 19 small) were counted in pools not known to exist in previous years. However, these new pools were surveyed one day after the main dive survey of the rest of the river and thus could contain salmon that were already counted. As a result, two sets of estimates were calculated. One estimate took into account the salmon counted in the new pools and the other did not. The total number of salmon counted in 2011 was greater compared to 2010 for both small (10) and large (125) salmon.

An abundance time series for Atlantic salmon in Middle River was derived using a model that combines the recreational catch, dive survey, adult mark-recapture, and electrofishing data to estimate abundance using maximum likelihood (Gibson and Bowlby 2009). Although no obvious trend could be observed from the time series, estimated spawning escapement increased for the second consecutive year in 2011 to a value comparable to the highest values in the 26 year time-series (Figure 1). The spawning escapement in 2011 is estimated to be 186 small and 343 large salmon when omitting the salmon counted in the new pools when fitting the model; or 203 small and 364 large salmon when incorporating these salmon. In either case, both escapement estimates for 2011 were higher than last year's estimate of 53 small and 312 large salmon.

Estimates of the percent of the conservation egg requirement met annually show a similar pattern with very little chance that the population has met its conservation egg requirement at any time since 1983 (Figure 1). An assumption of 4% catch-and-release mortality is used in the assessment model; however, the majority of salmon are caught during October when water temperatures are low, and 4% is considered to be precautionary in this case. Based on the preliminary recreational catch estimate, the number of mortalities resulting from the recreational fishery is estimated to be 17 salmon (see sources of uncertainty). The percent of the conservation egg requirement met in 2011 is estimated to be 60% (without including dive count surveys in the new pools) or 64% (if including dive count surveys in the new pools). Overall, the analyses indicate a population in the range of 24 to 74% of its conservation egg requirement over the last 10 years.

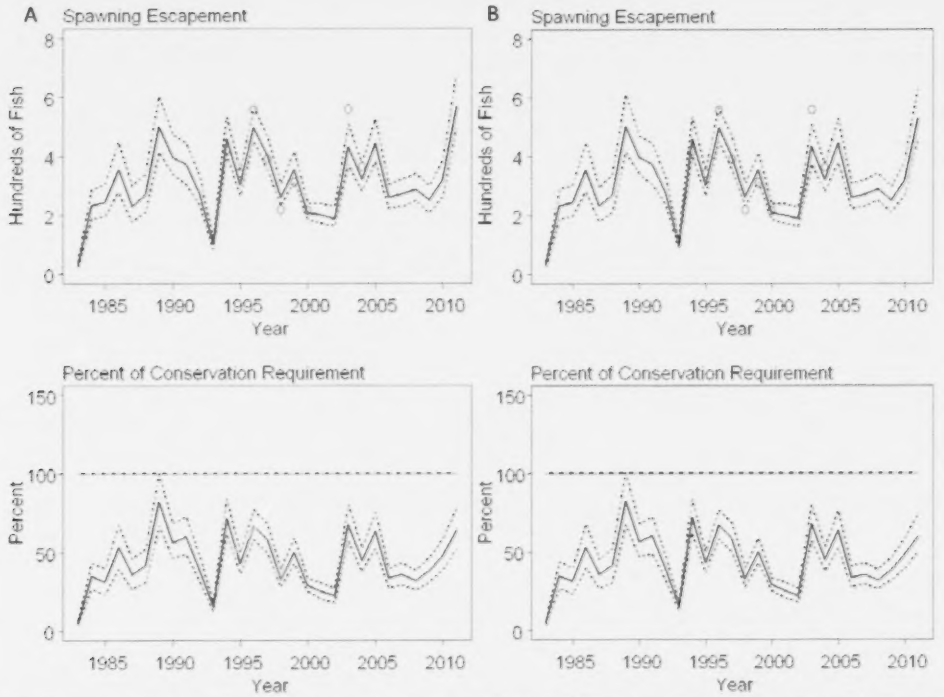


*Figure 1. Estimated total number of spawners (top graphs) and the percent of the conservation egg requirement attained (bottom graphs) in Middle River, NS, from 1983 to 2011. Panel **A** show the model run without including the dive counts from the new pools while panel **B** includes them. The solid lines are the estimated values and the dashed lines are the 10th and 90th percentiles of the posterior probability densities for the estimates (indicative of the uncertainty of the estimates). The points in the upper panel are the population estimates obtained by mark recapture during the dive surveys. The horizontal dashed line in the bottom panel indicates 100% of the conservation egg requirement.*

The assessment methods and data available for Atlantic salmon in **Baddeck River** are similar to those for Middle River. The conservation egg requirement for the Baddeck River is 2.0 million eggs, calculated based on an estimated 836,300 m^2 of habitat and a target egg deposition density of 2.4 eggs/m^2. This egg deposition is expected from about 450 large and 80 small salmon (O'Connell et al. 1997).

In 2011, the preliminary estimate of the recreational catch was 138 small (including 3 retained) and 317 large salmon with an estimated effort of 711 rod days (Appendix 4). The catch of both small and large salmon was higher in 2011 than in 2010, but the effort was also 86% greater. Analysis of the recreational fishing data series indicates that fishing effort has shown an increasing trend over the last ten years.

In 2011, eight salmon (one small, seven large) were removed from the population for use as broodstock in a stocking program. The stocking program was designed to offset anticipated future losses to the population from catch-and-release mortality. A total of 6,000 fry resulting from last year's broodstock collection were released into the Baddeck River on July 20, 2011, and an additional 10,700 fin clipped age-0 fall parr were released on October 17, 2011, as part of this program. Adult returns associated with these releases are expected in three to seven years. In addition, parr were collected from a provincial stocking program, grown to adults by DFO, and the first release of two adults was in 2011 with an aim to support Food, Social, and Ceremonial use.

The numbers of large and small salmon counted during dive surveys in Baddeck River from 1994 to 2011 provide indices of spawning escapement for this population. These surveys typically take place during the last week of October, just prior to the end of the fishing season. During the dive survey in (October 25, 2011) 39 small and 121 large salmon were counted; both of these counts are higher than the dive survey counts for 2010 (e.g., two small and 40 large salmon) and 2009 (e.g., 15 small and 67 large salmon).

Annual estimates of salmon escapement after the recreational fishery show an increasing trend until 1996, followed by a gradual decrease to 2010 and an increase in 2011 (Figure 2). The spawning escapement in 2011 is estimated to be 111 small and 317 large salmon, which is greater than last year's escapement estimate of 31 small and 190 large salmon.

Estimates of the percent of the conservation egg requirement met annually show a similar pattern with very little chance that the population has met its conservation egg requirement since 1983 (Figure 2). An assumption of 4% catch-and-release mortality is used in the assessment model; however, the majority of salmon are caught during October when water temperatures are low, and 4% is considered to be precautionary in this case. Based on the preliminary recreational catch estimate, the number of mortalities as a result of the recreational fishery in the Baddeck River is estimated to be 22 salmon (see sources of uncertainty). The percent of the conservation egg requirement met in 2011 is estimated to be 84%. Overall, the analyses indicate that the escapement estimate in 2011 is the highest since 1996.

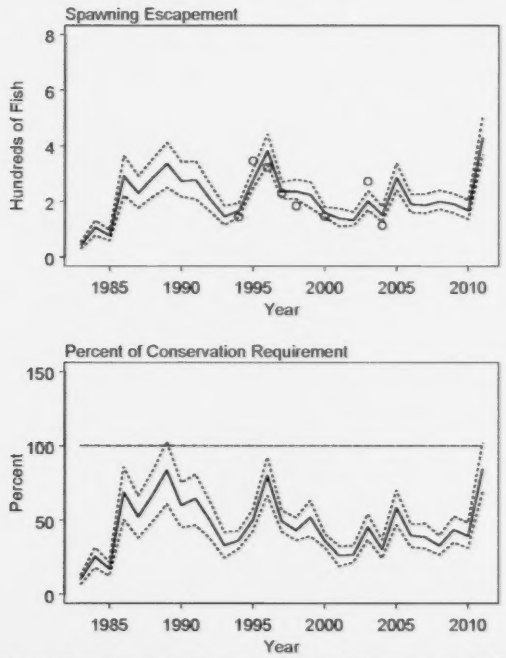


Figure 2. Estimated total number of spawners (top panel) and the percent of the conservation egg requirement attained (bottom panel) in Baddeck River, NS, from 1983 to 2011. The solid lines are the estimated values and the dashed lines are the 10th and 90th percentiles of the posterior probability densities for the estimates (indicative of the uncertainty of the estimates). The points in the upper panel are the population estimates obtained by mark recapture during the dive surveys. The horizontal dashed line in the bottom panel indicates 100% of the conservation egg requirement.

Clyburn Brook is found on the eastern side of Cape Breton Highlands National Park near Ingonish. The river runs over a length of 19.4 km and is estimated to contain 116,500 m^2 of habitat (O'Connell et al. 1997). Parks Canada has conducted annual dive surveys on this river from 1987 to 2011. The counts of large and small salmon are done at the end of the fishing season. The observation efficiency is not known; however, the time series provides a relatively consistent index of abundance for this river. In some years, less area is covered during the survey than in others. Counts in this river were highest in 1987, at 175 salmon, and have only exceeded 20 salmon twice since 1999 (Figure 3). Only two small salmon were counted this year, but the survey took place later than usual (December 1, 2011) and the water flow was very fast during the survey. Incidental sightings of eleven adult salmon from August to October indicate that the run might have been in the river earlier this year due to some heavy rains in July and August.

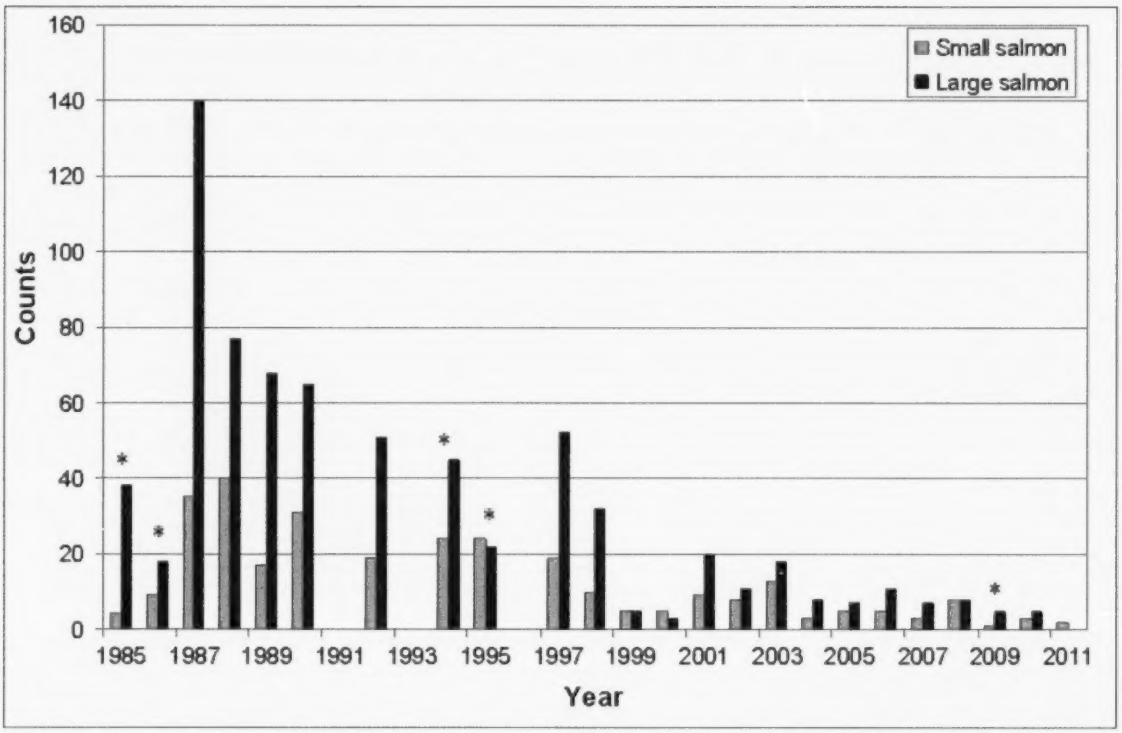


Figure 3. Counts of large and small salmon in Clyburn Brook, NS, from 1985 to 2011. Years in which only the lower section of the river was surveyed (partial counts) are identified with an asterisk (*).

Similar to the Middle and Baddeck rivers, recreational catch estimates from license stub returns and counts of adult salmon made by divers are available for assessing the status of salmon in **North River**. The current conservation egg requirement of 0.85 million eggs for the North River is based on a target egg deposition density of 2.4 eggs/m^2 and an estimated 355,900 m^2 of habitat (as listed in Amiro and Marshall 1990), and not based on the estimated 382,700 m^2 listed in previous assessments. O'Connell et al. (1997) used an alternate measurement of 382,700 m^2 and corresponding requirement of 0.92 million eggs from 215 large and 32 small salmon. By contrast, the conservation egg requirement used here (0.85 million eggs) is based on a requirement of about 200 large and 30 small salmon (as listed in Marshall et al. 1992).

In 2011, the preliminary estimate of the recreational catch was 203 small salmon and 489 large salmon with an estimated effort of 825 rod days (Appendix 4). The effort was 31% higher in 2011 than in 2010 (629 rod days), and the total catch was 57% higher in 2011 than in 2010

(35% higher for small salmon and 67% for large salmon). Analysis of the recreational fishing data series indicates that fishing effort has shown an increasing trend over the last ten years. Dive survey counts in North River are not conducted every year because of water conditions. Counts have been completed in six years since 2001 and have ranged from 12 to 117 salmon. Counts from 1994 to 1998 ranged from 167 to 335 salmon. During the dive survey in 2011, 14 small and 37 large salmon were counted, although the results were judged not to be useful for the estimation of abundance because of unsuitable water conditions. There is low confidence in dive survey results given the high water levels and the characteristics of this river, including poor visibility (e.g., tea-colored water and large pool size) that leads to high variability in observation rate.

Returns to North River in 2011 were estimated using the preliminary recreational catch data and mean catch rates (ratio of the recreational catch to the estimated returns) for this river. Based on these rates (0.41 for large and 0.69 for small salmon), the estimated returns were 1,193 large and 294 small salmon.

The 2011 large and small salmon estimates are both greater than those for 2010 (712 large and 217 small). Assuming a 4% mortality rate, which is considered less precautionary on the North River because of the higher temperatures expected in a summer fishery, and based on the preliminary estimated recreational catch, the number of mortalities as a result of the recreational fishery is estimated to be 28 salmon. This population has shown a declining trend since the 1980s, although estimates have been slowly increasing since 2006. Based on the recreational catch, it appears to be above its conservation egg requirement at present (Figure 4).

The status of salmon in the **North Aspy River** was assessed by a dive survey for the first time in 2009, where 28 small and 126 large salmon were observed. No dive survey was conducted in 2010 due to high water. A dive survey was conducted in 2011 but the results were deemed unsuitable for abundance estimation due to high flow and poor visibility. The preliminary estimates of the recreational catch in 2011 were 3 small and 15 large salmon with an estimated effort of 43 rod days (Appendix 4). Based on the preliminary recreational catch estimate, the number of mortalities as a result of the recreational fishery in North Aspy River (4% mortality rate assumed) is estimated to be one salmon. No recreational catch or effort data were reported for the North Aspy River in 2009, but, in 2010, 12 small and 14 large salmon were caught and released with an estimated effort of 70 rod days (Appendix 4). The 2011 salmon angling season on the North Aspy River ran from June 1 to July 15 and again from September 1 to October 31. The known reported recreational fishing effort has occurred in September and October on the North Aspy River over the last 10 years.

Even though the **Barachois River** was closed for angling all year, six small salmon were reported caught and release for an effort of 22 rod days.

In conclusion, only one of the three index rivers in SFA 19 (North River) met the conservation egg requirement in 2011. A preliminary estimate of the number of salmon caught and released in SFA 19 in 2011 was 1,526 fish (Appendix 4). This is an increase from last year's estimate of 977 salmon caught. Recreational effort has been increasing in SFA 19 over the past 10 years.

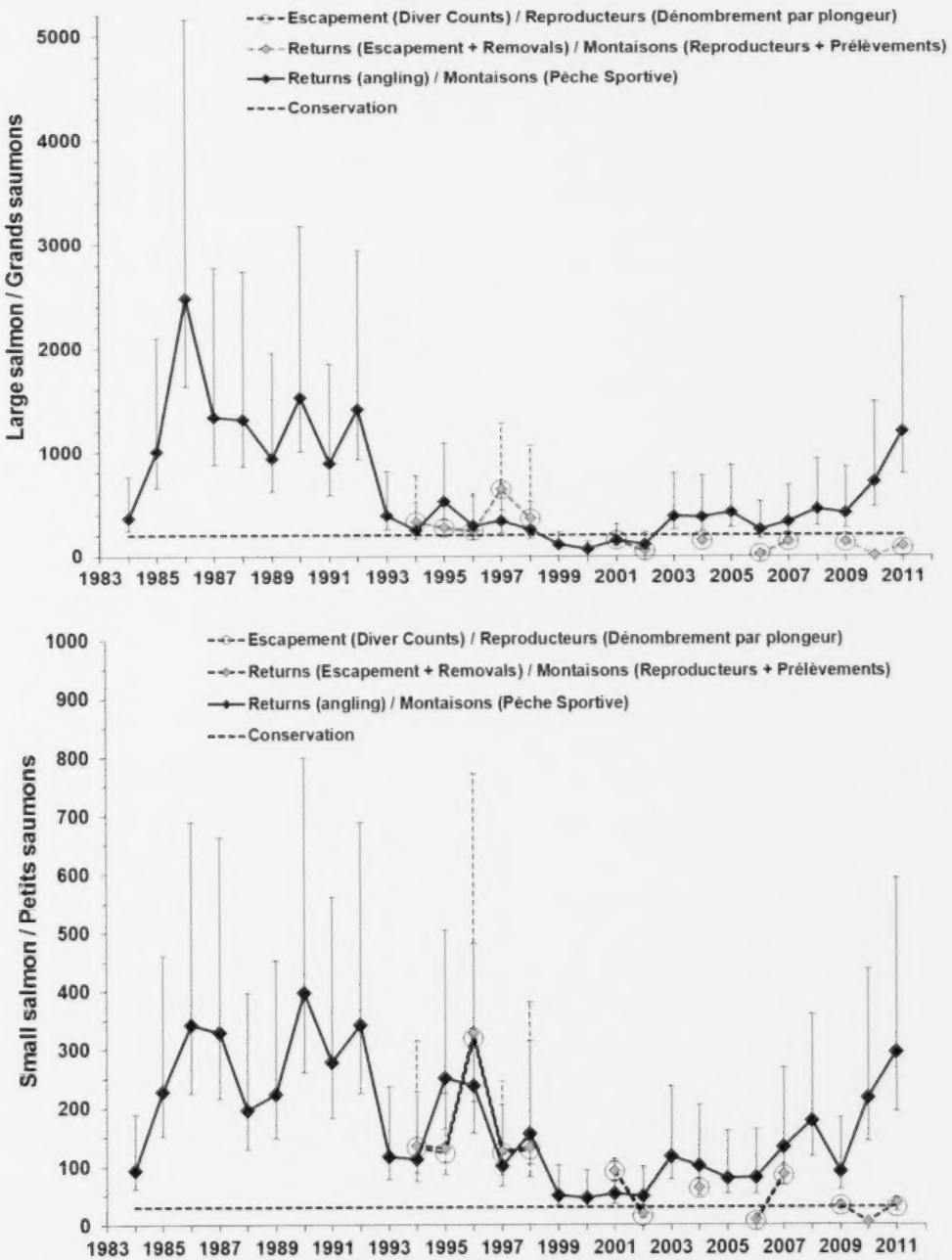


Figure 4. Estimates of the number of salmon returning to spawn and the spawning escapement for large and small salmon in the North River, NS, as derived from dive survey counts and from recreational catch data. The expected number of large or small salmon necessary to meet the conservation requirement is shown by the horizontal dashed line. Error bars are 90% confidence intervals.

Southern Upland of Nova Scotia (SFAs 20 and 21)

The Southern Upland (SU) region of Nova Scotia includes all rivers on the Eastern Shore and Southwest Nova Scotia draining into the Atlantic Ocean. It has been divided into two SFAs for management purposes: SFA 20 (Eastern Shore) and SFA 21 (Southwest Nova Scotia) (Appendix 2). Within the previous century, 63 rivers in the Southern Upland are known to have supported anadromous Atlantic salmon populations. Based on pH samples collected in the early 1980s, at least 14 of these rivers were heavily acidified (pH < 4.7) and were no longer able to support salmon (DFO 2000). A further 20 rivers were partially acidified (pH ranges from 4.7 to 5.0) and were thought to support only remnant populations. A region-wide electrofishing survey conducted in 2000 found salmon in 28 of 52 rivers surveyed (54%). A similar survey conducted in 2008 and 2009 found salmon in only 21 of 54 rivers surveyed (39%).

Atlantic salmon assessment activities in the SU region are focused primarily on two populations: the **St. Mary's River**, the index population for SFA 20, and the **LaHave River**, the index population for SFA 21 (Appendix 1). In 2011, all rivers within SFA 20 and SFA 21 were closed to recreational fishing for Atlantic salmon (Appendix 2). Additional information about these assessments is provided in Gibson et al. (2009).

Status

The **St. Mary's River** is one of the major river systems in SFA 20 and consists of two main branches: the West and East. Although alternate calculations exist (O'Connell et al. 1997), the conservation egg requirement used for assessments on the St. Mary's River is 7.4 million eggs, which is equivalent to approximately 3,155 adult salmon (O'Neil et al. 1998, Amiro et al. 2006). This egg requirement is based on the estimated habitat area (3,078,500 m^2) suitable for juvenile production in the river (O'Neil et al. 1998) and a target egg deposition rate of 2.4 eggs/m^2 (Marshall 1986; O'Connell 1987). However, assessment activities in the St. Mary's River are focused on the West Branch of the river, which contains 55% of the juvenile salmon habitat available in the watershed (1,693,175 m^2), which is equivalent to 1,735 adult salmon (Amiro 1993; Amiro et al. 2000).

Escapement estimates (Table 2) for the river are based either on the recreational catches (1996 and earlier), adult mark-recapture experiments (1997 to 2001, 2006 to 2008 and 2010), and/or on the ratio of escapement estimates for the West Branch of the St. Mary's relative to the LaHave River above Morgan Falls (2009, 2010 and 2011). From 2002 to 2005, mark-recapture experiments were attempted but were unsuccessful, and escapement estimates in these years were derived using the mean catch rate for seining during years when the mark-recapture experiments were successful.

In 2011, a total of 70 adult salmon were seined during the marking pass, but no mark and recapture experiment was performed due to unsuitable water conditions for the recapture pass. Based on the scale samples taken from captured fish, 96% of the population was comprised of one-sea-winter salmon, 4% was comprised of two-sea-winter salmon, and there were no repeat spawners. In 2011, the mean catch rate of mark and recapture experiments for years 2006-2008 and 2010 (0.37) was used to estimate the 2011 escapement for the West Branch of the St. Mary's River and the ratio of 1SW (one-sea-winter) to MSW (multi-sea-winter) found during seining in 2011 (0.96 for 1SW and 0.04 for MSW) was applied to the escapement estimate (Table 1). Using this assessment method, 182 1SW and 8 MSW salmon were estimated for 2011. When using the ratio of escapement of Saint Mary's to LaHave method (DFO 2011), 168 1SW and 21 MSW salmon were estimated to have returned in 2011. Both methods estimated the total eggs deposited from the number of salmon returning in Saint Mary's River to

represent 11% of the conservation egg requirement for the West Branch of the St. Mary's River. In 2010, the ratio of escapement of St. Mary's to LaHave River assessment method yielded the same percentage (11%) of the conservation egg requirement, but the mark and recapture experiments approach lead to a lower estimate (5%).

Table 2. Estimated escapement of one-sea-winter (1SW) and multi-sea-winter (MSW; including both two-sea-winter and repeat spawning salmon) Atlantic salmon relative to the conservation egg requirement in the West Branch of the St. Mary's River for the years 1995 to 2011.

Year	1SW	MSW	% Conservation Egg Requirement	Assessment Method
1995	1,121	240	78	Recreational Catches
1996	844	325	67	Recreational Catches
1997	390	61	26	Adult Mark-Recapture Experiments
1998	1,059	41	63	Adult Mark-Recapture Experiments
1999	307	83	22	Adult Mark-Recapture Experiments
2000	315	25	20	Adult Mark-Recapture Experiments
2001	319	106	24	Adult Mark-Recapture Experiments
2002	220	16	14	Seining and Mean Mark-Recapture Catch Rate
2003	600	122	42	Seining and Mean Mark-Recapture Catch Rate
2004	464	23	28	Seining and Mean Mark-Recapture Catch Rate
2005	192	8	12	Seining and Mean Mark-Recapture Catch Rate
2006	222	18	14	Adult Mark-Recapture Experiments
2007	182	23	12	Adult Mark-Recapture Experiments
2008	361	36	23	Adult Mark-Recapture Experiments
2009	96	15	6	Ratio of Escapement of St. Mary's to LaHave
2010	75[a] / 171[b]	14[a] / 15[b]	5[a] / 11[b]	[a] Adult Mark-Recapture Experiments / [b] Ratio of Escapement of St. Mary's to LaHave
2011	182[a] / 168[b]	8[a] / 21[b]	11[a] / 11[b]	[a] Seining and Mean Mark-Recapture Catch Rate [b] Ratio of Escapement of St. Mary's to LaHave

Based on electrofishing data from 12 sites in 2011, estimated densities (fish per 100 m^2) of age-0 (fry), age-1 and age-2 and older juvenile salmon were 12.9, 5.1 and 0.3 respectively for the entire St. Mary's River, which is higher than 2010 for fry (7.7), lower for age-1 parr (5.8), and the same for age-2 parr (0.3). These values are low relative to densities observed in rivers where adult salmon abundance is above their conservation egg requirement. All density estimates were calculated using the mean age-1 efficiency for years 2007-2011, which is derived from mark-recapture experiments.

In order to ensure that intervention programs, such as supportive rearing or live gene banking, remained as options in case of future population decline, DFO collected juvenile salmon (fry and parr) from the St. Mary's River in 2006 and 2007 for rearing at the Coldbrook Biodiversity facility. These collections were undertaken as an "insurance policy" to ensure that fish were collected while there was still sufficient genetic diversity in the event that an intervention would be necessary to slow population decline. In 2008, 201 of the collected juveniles reached maturity and were released at four sites on the St. Mary's River so they could spawn naturally. In 2009, a further 212 adult salmon that had reached maturity were released at eight sites along the West Branch and its tributaries. The final adult releases from these collections occurred in 2010, where 114 adult salmon were released at five sites along the West Branch and its tributaries. The potential contribution of the adult releases in 2008-2010 to West Branch juvenile densities should be considered in future assessments.

A smolt assessment was attempted this year in the St Mary's River but was discontinued as the wheel had to be raised for a number of days due to high water.

Assessment activities on the **LaHave River**, the index river for SFA 21, include counts of salmon ascending a fish ladder at Morgan Falls, smolt abundance estimates at Morgan Falls, and juvenile densities obtained by electrofishing. The population above Morgan Falls increased as a result of improved fish passage with the construction of a fish ladder in the late 1960s. Salmon were stocked in the river above Morgan Falls to augment population growth, but stocking was terminated in 2005. The estimated number of spawners to reach the egg deposition requirement for the entire LaHave River (3,312 salmon) is based on 2.4 eggs/m^2 deposition rate, an estimated rearing habitat of 2,046,228 m^2, and an average fecundity of 1,482 eggs per fish (Cutting and Grey 1984). If these same rates are applied to only 40% of the rearing habitat (as has been done in the past to account for acidification in that section), this would be equivalent to 1.96 million eggs and roughly 1,320 salmon (Amiro et al. 1996; Amiro et al. 2006).

The total count of adult salmon at the Morgan Falls fishway on the LaHave River in 2011 was 370 (294 1SW and 76 MSW salmon) (Figure 5). This represents an increase in total returns from 2010. The count of 1SW salmon ascending the Morgan Falls fishway in 2011 was slightly lower (294) than in 2010 (300); whereas, the MSW salmon count was 1.4 times greater (76) than the count in 2010 (53). Assuming 40% useable habitat, the estimated egg deposition above Morgan Falls would be 1,049,258 eggs in 2011, which would represent 54% of the conservation egg requirement (Amiro et al. 1996; Amiro et al. 2006; Figure 6). If the total habitat is assumed to be available, the estimated egg deposition above Morgan Falls would be 21.4% of the conservation egg requirement (Figure 6)

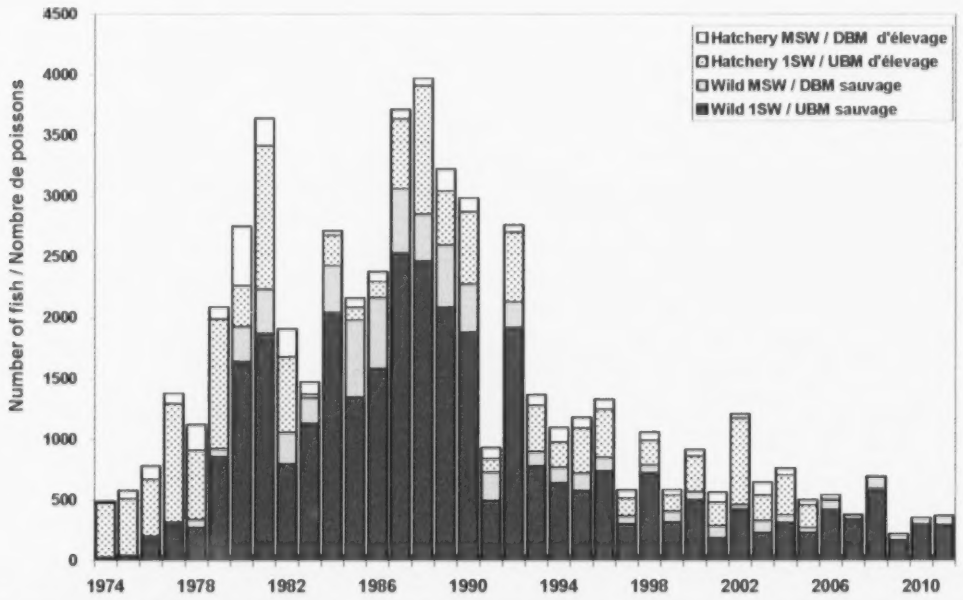


Figure 5. Counts of Atlantic salmon at Morgan Falls fishway on the LaHave River, NS, from 1974 to 2011 by wild-origin and hatchery-origin 1SW and MSW adults.

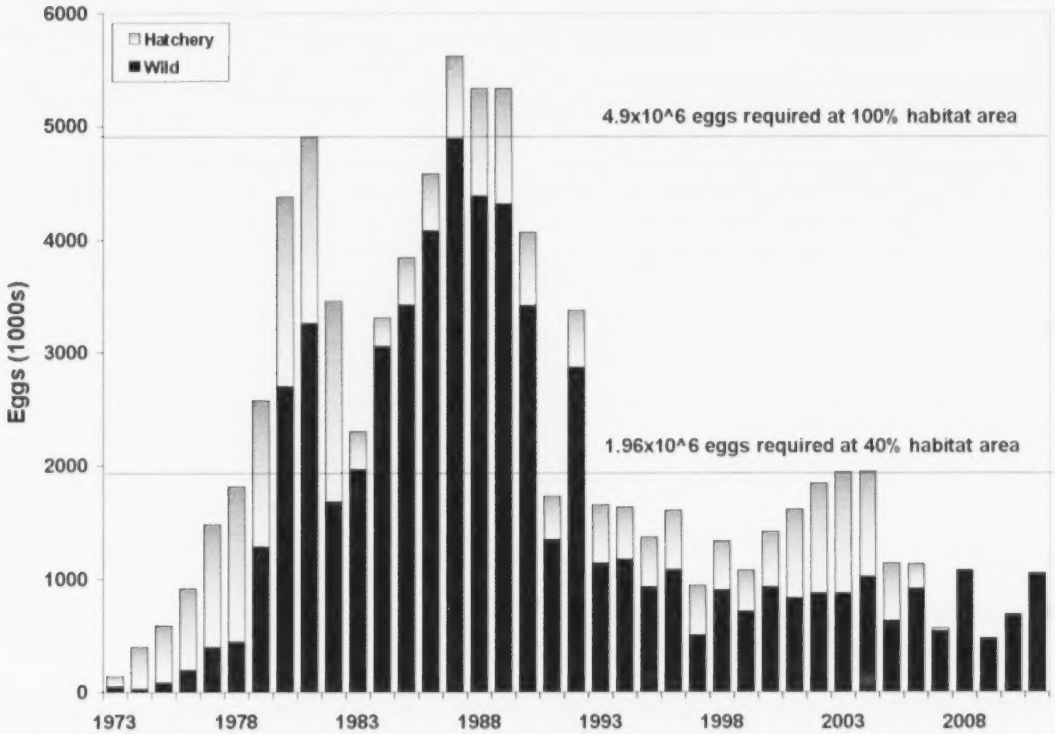


Figure 6. Estimated egg deposition (1000's) relative to the conservation egg requirement by wild and hatchery-origin Atlantic salmon above Morgan Falls from 1973 to 2011.

No smolt population estimate was conducted in 2011 due to lack of resources. In 2010, a total of 16,215 wild smolts (95% C.I. = 15160, 17270) were estimated to have emigrated from above Morgan Falls.

Based on electrofishing data from eleven sites in 2011, estimated densities (fish per 100 m^2) of age-0 (fry), age-1, age-2 and older juvenile salmon were 3.0, 3.3, and 0.9 respectively for the entire LaHave River, which is lower than 2010 for fry (17.0) and age 1 parr (11.9) but higher than 2010 for age-2 and older parr (0.5). Also, the mean fry density in 2011 was lower than the 5-year mean fry density by 89% above Morgan Falls and by 83% below Morgan Falls (Figure 7) and should be re-evaluated next year.

In conclusion, the two index rivers for SFA 20 and 21 are both well below their conservation egg requirements. The Saint Mary's River was estimated to be at 11% of the conservation egg requirement using two assessment methods. The LaHave River was estimated to be at either 54% (assuming 40% usable habitat) or 21% (assuming 100% useable habitat) of the conservation egg requirement. All rivers within SFA 20 and 21 are currently closed to recreational salmon fishing.

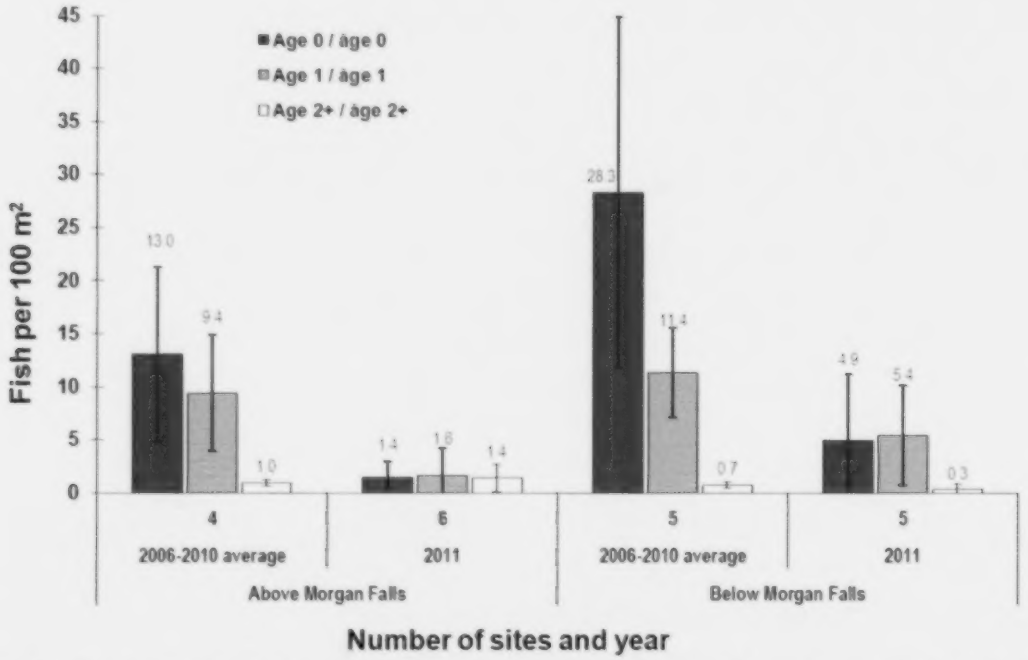


Figure 7. Mean density for the three age classes of juvenile salmon (age-0, age-1, and age-2+) above and below Morgan Falls on the LaHave River during in 2011 compared to the past 5-year average 2006-2010. The number of sampling sites on which the mean is based is listed immediately below the x-axis.

Outer Bay of Fundy (SFA 23)

The outer Bay of Fundy rivers in SFA 23 include those between the Saint John River and its tributaries and the St. Croix River, inclusively, and are bounded on the east by the endangered inner Bay of Fundy populations and on the west by salmon populations in Maine that are listed as endangered under United States legislation. The entire SFA 23 has been closed to commercial fishing for Atlantic salmon since 1984. Low abundance of salmon has resulted in the complete closures of the Aboriginal fisheries for food, social and ceremonial purposes, and the recreational fisheries since 1998. Assessment data in SFA 23 are collected for three index populations: the **Saint John River** upriver of Mactaquac Dam, the **Nashwaak River** and the **Magaguadavic River**. The Magaguadavic River data was provided by the Atlantic Salmon Federation. In the past, the St. Croix River was assessed annually, but the fishway has not been monitored since 2006. About 38% of the total accessible salmon habitat (wetted area) within SFA 23 is upriver of Mactaquac Dam. Further detail about these assessments is provided in Jones et al. (2010).

The Mactaquac Biodiversity Facility has been involved in the mitigation of salmon lost to hydroelectric projects on the Saint John River, primarily via smolt production. Historically, hatchery broodstock for the program has consisted of 200-300 wild sea-run adults each year. The program at the Mactaquac Biodiversity Facility has been re-focused to the singular objective of conserving and restoring a declining resource (Jones et al. 2004). Thus, discussion among DFO, with the Saint John River Management Advisory Committee and the Saint John Basin Board resulted in a program change in 2004. The new program replaces a large portion of the traditional smolt production with production of age-0 fall parr and furthermore, utilizes captive reared wild-origin juveniles that are used for broodstock and for release and natural spawning upriver of Mactaquac.

Status

The conservation egg requirement for salmon populations in **the Saint John River upriver of Mactaquac Dam** is based on an accessible rearing area of 13,472,200 m^2. This does not include the Aroostook River, headponds, or the 21 million square meters of river with gradient <0.12%. Based on a required egg deposition of 2.4 eggs/m^2, the conservation egg requirement is 32.3 million eggs. The number of spawners necessary to obtain the conservation egg requirement is estimated to be 4,900 MSW and 4,900 1SW salmon (Marshall et al. 1997).

Counts at Mactaquac Dam consist of fish captured at the fish collection facilities at the Mactaquac Dam and at the smolt migration channel at the Mactaquac Biodiversity Facility. During 2011, these facilities were operated from May 25 to October 31.

Total returns of 1,019 1SW and 678 MSW salmon, destined for upriver of Mactaquac Dam on the Saint John River in 2011, were both well below returns observed in most years since 1970 (Figure 8). The 1SW returns (wild and hatchery combined) in 2011 were the third lowest since 1970 and only 43% of the numbers observed in 2010. The MSW returns were the highest observed since 2004 but continue to be very low relative to past abundance. Wild-origin fish (which could include progeny from captive-reared adults released for natural spawning in 2005, 2006 and 2007) comprised 57% of 1SW and 43% of MSW fish.

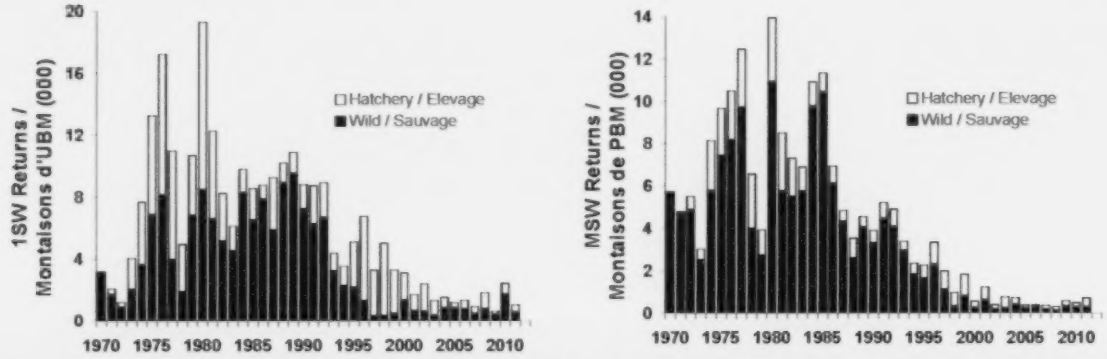


Figure 8. Estimated total returns of wild and hatchery-origin 1SW and MSW salmon destined for upriver of Mactaquac Dam, Saint John River, 1970 - 2011.

Five repeat-spawning, captive-reared salmon were also captured at the Mactaquac fishway in 2011. No suspected aquaculture escapes were counted in 2011, which was encouraging considering 26 suspected escapes were captured at Mactaquac in 2010.

Removals from the returns destined for production areas upriver of Mactaquac include: 1) the estimate of 1SW and MSW salmon ascribed to by-catch in the estuary (Marshall and Jones 1996) , 2) salmon passed or trucked upriver of Tinker Dam on the Aroostook River, 3) salmon retained at Mactaquac as broodstock for conserving the Serpentine strain, 4) salmon estimated to have been lost to poaching activities, in particular those taken by illegal nets just below the Tobique and Mactaquac dams, and 5) known mortalities due to handling operations at Mactaquac, at fishways (Beechwood, Tobique and Tinker Dam), and at the Tobique Half Mile Barrier (Table 3).

Table 3 Estimated removals of 1SW and MSW salmon destined for upriver of Mactaquac Dam on the Saint John River, N.B., 2011.

	Estimated Removals		Percent of Total Returns	
Component	1SW	MSW	1SW	MSW
By-catch Estimates	10	17	1.0	2.5
Passed above Tinker Dam	23	9	2.3	1.3
Hatchery Broodstock	0	0	0.0	0.0
Poaching Estimates	29	24	2.8	3.5
Mortality at Mactaquac	8	7	0.8	1.0
Mortality at Beechwood	1	4	0.1	0.6
Mortality at Tobique	0	2	0.0	0.3
Mortality at Tinker	0	0	0.0	0.0
Mortality at Tobique Barrier	0	0	0.0	0.0
Total	71	63	7.0	9.2

The resulting spawning escapement is estimated to be 948 1SW and 615 MSW salmon, which resulted in an egg deposition estimate (44% from wild fish) equivalent to 13% of the conservation egg requirement, an increase from the previous six years (2005-2010) and similar to the estimates observed in 2003 and 2004 (Figure 9). The Serpentine 2SW salmon were released upriver of Mactaquac in 2011 as part of a collaborative radio tracking project (Woodstock First Nation, Atlantic Salmon Federation and DFO); therefore, no sea-run 1SW or MSW salmon were retained for conservation initiatives in 2011. Captive-reared adults, with the potential to produce an additional 3.8 million eggs (or 11% of the conservation egg requirement), were released upriver of Mactaquac (majority in the Tobique River) in 2011 (Figure 9).

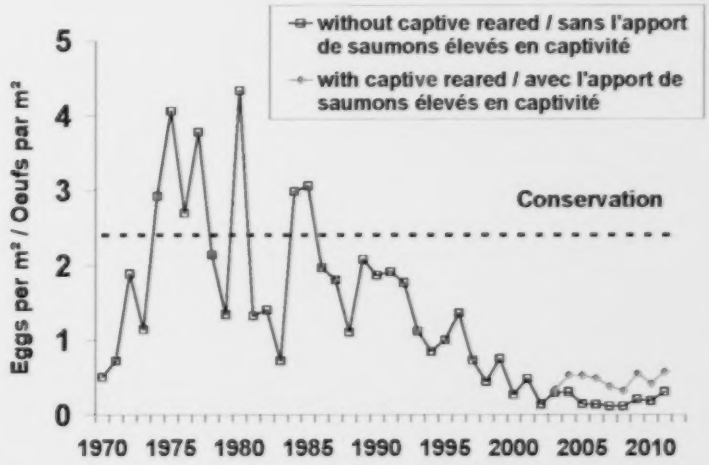


Figure 9. Estimated egg deposition (wild and hatchery combined, and captive reared) upriver of Mactaquac Dam, Saint John River, 1970 - 2011.

The **Nashwaak River** is the largest single salmon-producing tributary of the Saint John River downriver of Mactaquac Dam; it contains 28.5% of the total salmon production area in the Saint John River downriver of Mactaquac Dam. A salmon counting fence, located 23 km upriver from the confluence with the Saint John River, was operated by DFO in 1972, 1973 and 1975, and by DFO in cooperation with Kingsclear, Oromocto, St. Mary's, and Woodstock First Nations from 1993 to 2011. In 2011, the fence was jointly operated by Kingsclear and Oromocto First Nations and DFO. The salmon production area upriver of the fence is estimated to be 5.35 million square meters (90% of the total river estimate), and the conservation requirement is 12.8 million eggs. The number of spawners necessary to obtain the conservation egg requirement is estimated at 2,040 MSW and 2,040 1SW salmon (Marshall et al. 1997).

Counts of 417 1SW and 232 MSW salmon at the Nashwaak River fence, combined with seining of upriver holding pools, resulted in a mark-recapture estimate of 1,034 1SW and 576 MSW salmon returning to this river (Figure 10). Multi-sea-winter returns in 2011 were three times higher than 2010 and the second highest since monitoring resumed in 1993. Whereas, the 1SW returns were 50% lower than 2010 but were the third highest estimate observed in the past decade or so. Wild-origin fish comprised 95% of 1SW and 97% of MSW fish. No suspected aquaculture escapes were captured at the counting fence or during seining in 2011.

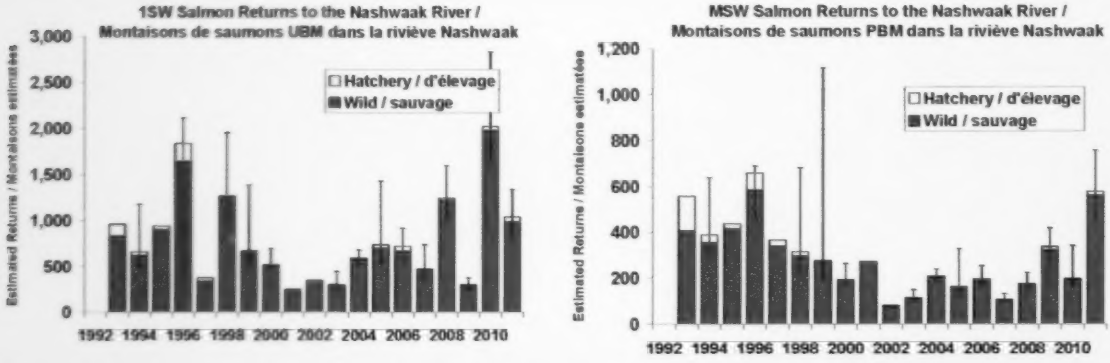


Figure 10. Estimated wild and hatchery 1SW and MSW salmon returns (and 2.5 and 97.5 percentiles) to the Nashwaak River, 1993-2011.

Spawning escapement is estimated by subtracting the known removals from the estimated returns. There were three 1SW and one MSW salmon mortalities observed while the counting fence was in operation in 2011. DFO fishery officers reported that no salmon were known to have been removed by illegal fishing activities within the Nashwaak watershed. No 1SW or MSW salmon were removed from the fence trap for conservation initiatives by the Nashwaak Watershed Association Inc. in 2011. After removing the four fish from the estimated returns, the estimated number of spawners was 1,031 1SW and 575 MSW. In 2011, the egg deposition estimate of 4.7 million, representing 37% of the conservation egg requirement, was the highest value since 1996 (Figure 10). One-sea-winter females contributed 35% of the total egg deposition. Hatchery fish contributed 2% of the total egg deposition.

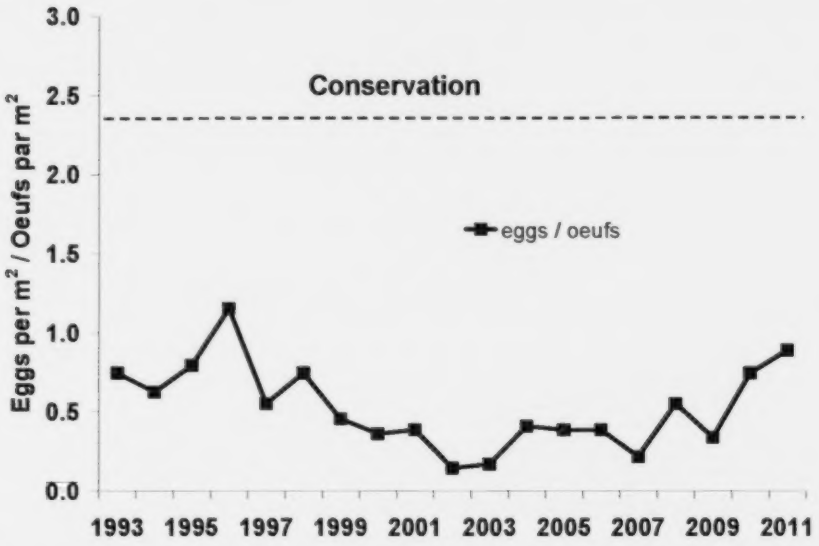


Figure 10. Estimated egg deposition upriver of the counting fence operated just below Durham Bridge, Nashwaak River, 1993 - 2011.

Wild smolt production in the Nashwaak River has been monitored since 1998. The number of wild smolts emigrating from upriver of the adult counting fence in 2011 was estimated to be 8,750 (95% C.I. = 7,130 to 11,300). The total number of wild smolts was 70% of the 2010 value and 53% of the previous five-year mean.

Returns to the St. George fishway and trap located near the head of tide on the **Magaguadavic River** in 2011 were eight 1SW and eleven MSW salmon. All 19 1SW and MSW salmon (wild and hatchery origin combined) were released to the river and potentially deposited an estimated 55,179 eggs. The conservation egg requirement is estimated to be 1.35 million eggs from 140 1SW and 230 MSW salmon (Anon 1978). Thirty-two captive-reared adults resulting from conservation initiatives of the Atlantic Salmon Federation were released in 2011, potentially depositing an additional 152,000 eggs (or 11% of conservation egg requirement). There were 17 1SW aquaculture escapes captured at this facility in 2011.

For the Saint John River upriver of Mactaquac, the 2011 egg deposition was 13% of the conservation egg requirement. The Nashwaak River is at 37% of the conservation egg requirement. The Magaguadavic River is at 4% of the conservation egg requirement.

Sources of Uncertainty

The number of salmon harvested under Aboriginal fishing agreements in SFA 19 is not available at the time of this assessment (Aboriginal fisheries in SFAs 20, 21 and 23 are currently closed). Removals of salmon under these agreements, based on anecdotal information and information provided by Departmental staff, are not thought to be substantial and are believed to remain below current allocations.

There are anecdotal reports of poaching, but its contribution to the depressed status of populations in this region is not known.

Spawning escapement for Middle and Baddeck rivers is derived using a model that combines the recreational catch, dive survey, adult mark-recapture and electrofishing data to estimate abundance using maximum likelihood (Gibson and Bowlby 2009). When this model was developed (using data to 2008), it fit both the recreational catch and dive count data very well. However, starting in 2009, and again in 2010, abundance estimates from the model based on the recreational catch are higher than those based on the dive surveys. This change in model performance occurred at the same time that most rivers in SFA 19 were closed to recreational salmon fishing and at a time when fishing efforts in Middle and Baddeck rivers were the highest since the early 1990s. As a result of the disparity between the recreational catch and the dive counts, the predicted recreational catch using the old model formulation did not track the observed recreational catch as well for 2009, 2010 and 2011 although fits to the dive surveys remained good. In 2011, to achieve a better fit to the recreational catch, the variance terms of the likelihood functions were adjusted giving more equivalent weightings to the recreational catch and dive counts. This resulted in abundance estimates from the model that are higher than if this adjustment had not been made.

An assumption of 4% catch-and-release mortality is applied to rivers assessed in SFA 19. This value is considered precautionary in the Middle and Baddeck rivers where angling is restricted to the month of October, when water temperatures are generally cold. The value is thought to be less precautionary for the North River, where fishing occurs in the summer during periods of higher water temperatures. Although studies suggest that mortality rates associated with catch-and-release angling at temperatures <12°C are thought to be <3%, the more precautionary value of 4% is used to account for other potential effects of catch-and-release salmon fishing (e.g. potential effects on migration, reproduction, habitat impacts, transfer of pathogens, and other delayed effects). The use of a more precautionary value also reflects the fact that current water temperatures during angling seasons in Cape Breton are not known and that some Cape Breton rivers remain below their conservation egg requirements.

The small size of the other rivers in SFA 19 makes their populations more vulnerable to the demographic and genetic effects of small population size, although no recent assessment work has been carried out in any of these rivers.

No recapture pass could be carried out for the St Mary's river in 2011. As a result, two proxies were used to estimate adult returns: mean mark-recapture catch rates from past years and an escapement ratio based on the LaHave river counts. Although both methods yielded corroborative estimates of escapement, the use of these proxies adds an additional measure of uncertainty.

The number of salmon caught and released within SFAs 19, 20 and 21 is estimated based on salmon license stub returns. There are anecdotal (but reliable) reports of salmon being caught and released by anglers fishing with a general recreational fishing license. Although the extent to which this is occurring is not known, the number of salmon caught and released each year in recreational fisheries, and hence mortality associated with the fishery, is likely underestimated. In 2011, DFO attempted to address the mortality angling associated with a General Fishing License through the implementation of pool closures on the Medway, Saint Mary's and LaHave rivers (angling prohibited). Under- or over-reporting may also affect population estimates based largely on angling data.

Conclusions

Overall, the information presented in this report does not outline a positive view of the status of Atlantic salmon in the eastern Cape Breton, Southern Upland, or outer Bay of Fundy areas. Only one of the three index rivers (North River) in SFA 19 met its conservation egg requirement in 2011. None of the other index rivers in SFAs 20, 21, or 23 met their conservation egg requirements in 2011.

The overall salmon population assemblage in eastern Cape Breton (SFA 19) is thought to be healthier than in the outer Bay of Fundy or Southern Upland regions. The North River salmon egg deposition was above its conservation egg requirement in 2011. Analysis of the recreational catch data for North River also showed an increase in the number of large and small salmon in 2011 compared to 2010. Although egg depositions in Middle and Baddeck rivers increased for the second consecutive year in 2011, they remain below their conservation egg requirements. The estimated escapement of grilse increased in both the Middle (186) and the Baddeck (111) rivers in 2011 relative to 2010 (from 31 and 53, respectively). Dive surveys in the North River have been conducted 12 times, including in 2011; however, due to river characteristics such as high water levels and poor visibility, which leads to high variability in observation rate, there has been low confidence in the results of these surveys. This approach is not recommended for monitoring of North River in the future. Although water conditions on the North Aspy River in 2011 rendered the results of dive counts unsuitable for abundance estimation, this river appears to be a good candidate for dive count surveys.

The available data and analyses for Southern Upland (SFA 20 and 21) populations indicate that some populations are presently extirpated and that the healthiest populations are at levels well below their conservation requirements. Based on an analysis provided in Gibson at al. (2011) the likelihood that populations in this area will extirpate is thought to be high in the absence of human intervention. Actions that improve freshwater productivity or smolt-to-adult survival are expected to increase viability and reduce recovery times once conditions are favourable for recovery. Similarly to rivers in SFA 19, estimated egg deposition increased for the second consecutive year in the LaHave and St. Mary's rivers.

Within the outer Bay of Fundy (SFA 23), egg deposition in the Saint John River upriver of Mactaquac Dam has been below the conservation egg requirement since 1985, despite closure of the commercial fishery in 1984 and recreational fishery in 1998; populations require supportive rearing to prevent extirpation. Actions that increase or improve freshwater productivity or survival from smolt to spawning are expected to increase viability, reduce the dependency on supportive rearing, and reduce recovery times once conditions are favourable for recovery. These include: reducing the poaching that is occurring in the system, in particular near the Mactaquac and Tobique Narrows dams, as well as increasing smolt survival by reducing turbine mortalities at each of the hydroelectric facilities affecting the upriver populations. The observation of aquaculture escapees at Mactaquac in 2010, as well as their on-going appearance on the Magaguadavic River are indications that extra actions to improve containment of aquaculture salmon are necessary if their interaction with wild stocks is to be reduced.

Contributors

Name	Affiliation
Marylise Lefèvre	DFO Maritimes Science
David Hardie	DFO Maritimes Science
Ross Jones	DFO Maritimes Science
Jamie Gibson	DFO Maritimes Science
Heather Bowlby	DFO Maritimes Science
Shane O'Neil	DFO Maritimes Science
Alex Levy	DFO Maritimes Science
Greg Stevens	DFO Maritimes Resource Management
Kurtis Trzcinski	DFO Maritimes Science
Tana Worcester	DFO Maritimes Science

Approved by

Alain Vézina
Regional Director, Science
Maritimes Region
Dartmouth, NS
(902) 426-3490

Date: May 8, 2012

Sources of Information

Anon. 1978. Biological Conservation Subcommittee Report. Atlantic Salmon Review Task Force. DFO Halifax, N.S. Vol 2: 203p.

Amiro, P.G. 1993. Habitat measurement and population estimation of juvenile Atlantic salmon (*Salmo salar*); pp. 81-97. *In* R.J. Gibson and R.E. Cutting [Eds.]. Production of juvenile Atlantic salmon, *Salmo salar*, in natural waters. Can. Spec. Publ. Fish. Aquat. Sci. 118.

Amiro, P.G., and T.L. Marshall. 1990. The Atlantic salmon resource of the North River, Victoria County, N.S. to 1984. Can. MS Rep. Fish. Aquat. Sci. 2075. 34 p.

Amiro, P.G., A.J.F. Gibson, and H.D. Bowlby. 2006. Atlantic salmon (*Salmo salar*) overview for eastern Cape Breton, Eastern Shore, Southwest Nova Scotia and inner Bay of Fundy rivers (SFA 19 to 22) in 2005. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/024.

Amiro, P.G., D.A. Longard, and E.M. Jefferson. 2000. Assessments of Atlantic salmon stocks of Salmon Fishing Areas 20 and 21, the Southern Upland of Nova Scotia, for 1999. DFO Can. Stock Assess. Sec. Res. Doc. 2000/009.

Amiro, P.G., E.M. Jefferson, and C.J. Harvie. 1996. Status of Atlantic salmon in Salmon Fishing Area 21, in 1995, with emphasis on the upper LaHave River, Lunenburg. Co., Nova Scotia. DFO Atl. Fish. Res. Doc. 96/126.

CAFSAC. 1991. Definition of conservation for Atlantic salmon. Canadian Atlantic Fisheries Scientific Advisory Committee Advisory. Document 91/15.

Cutting, R.E., and R.W. Grey. 1984. Assessment of the status of the Atlantic salmon stocks of the LaHave River, Nova Scotia. CAFSAC Res. Doc. 84/40.

Dempson, J.B., Furey, G. and Bloom, M. 2002. Effects of catch and release angling on Atlantic salmon, *Salmo salar* L., of the Conne River, Newfoundland. Fisheries Management and Ecology 9: 139–147.

DFO. 2000. The effects of acid rain on Atlantic salmon of the Southern Upland of Nova Scotia. DFO Maritimes Regional Habitat Status Report. 2000/2E.

DFO. 2009. A Fishery Decision-Making Framework Incorporating the Precautionary Approach. http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/precaution-eng.htm (Accessed April 11, 2012.)

DFO. 2011. Status of Atlantic Salmon in Salmon Fishing Areas (SFAs) 19-21 and 23. DFO Can. Sci. Advis. Sec. Sci. Resp. 2011/005.

Elson, P.F. 1975. Atlantic salmon rivers, smolt production and optimal spawning; an overview of natural production. International Atlantic Salmon Foundation Special Publication Series 6: 96-119.

Gibson, A.J.F., and H.D. Bowlby. 2009. Review of DFO Science information for Atlantic salmon (*Salmo salar*) populations in the eastern Cape Breton region of Nova Scotia. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/080.

Gibson, A.J.F., H.D. Bowlby, D.L. Sam, and P.G. Amiro. 2009. Review of DFO Science information for Atlantic salmon (*Salmo salar*) populations in the Southern Upland region of Nova Scotia. DFO Canadian Science Advisory Secretariat Research Document 2010/081.

Gibson, A.J.F., H.D. Bowlby, D.C. Hardie, and P.T. O'Reilly. 2011. Populations on the brink: Low abundance of Southern Upland Atlantic salmon in Nova Scotia, Canada. North Amer. J. Fish. Manag. 31: 733-741

ICES. 2010. Report of the Working Group on North Atlantic Salmon (WGNAS), 22–31 March 2010 Copenhagen, Denmark. ICES CM 2010/ACOM:09. 302 pp.

ICES. 2009. Report of the Working Group on North Atlantic Salmon (WGNAS), 30 March–8 April, Copenhagen, Denmark. ICES CM 2009/ACOM:06. 282 pp.

Jones, R.A., L. Anderson, A.J.F. Gibson, and T. Goff. 2010. Assessments of Atlantic salmon stocks in South Western New Brunswick (outer portion of SFA 23): An update to 2008. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/118: vi + 77 p.

Jones, R.A., L. Anderson, and T. Goff. 2004. Assessments of Atlantic salmon stocks in southwest New Brunswick, an update to 2003. Can. Sci. Advis. Sec. Res. Doc. 2004/019: ii + 70 p.

Marshall, T.L. 1986. Estimated spawning requirements and indices of stock status of Atlantic salmon in the St. Mary's River, Nova Scotia. CAFSAC Res. Doc. 1986/22.

Marshall, T.L., and R. Jones. 1996. Status of Atlantic salmon stocks of southwest New Brunswick, 1995. DFO Atlantic Fisheries Res. Doc. 96/40: iii + 50 p.

Marshall, T.L., R.A. Jones, and T. Pettigrew. 1997. Status of Atlantic salmon stocks of southwest New Brunswick, 1996. DFO Can. Stock Assess. Sec. Res. Doc. 97/27. iii + 67p.

Marshall, T.L., P.G. Amiro, J.A. Ritter, B. M. Jessop, R.E. Cutting, and S.F. O'Neil. 1992. Perfunctory estimates of allowable harvests of Atlantic salmon in 18 rivers of Scotia-Fundy Region. CAFSAC Res. Doc. 92/66.

O'Connell, M.F., D.G. Reddin, P.G. Amiro, F. Caron, T.L. Marshall, G. Chaput, C.C. Mullins, A. Locke, S.F. O'Neil, and D.K. Cairns. 1997. Estimates of conservation spawner requirements for Atlantic salmon (*Salmo salar* L.) for Canada. DFO Can. Stock Assess. Sec. Res. Doc. 97/100.

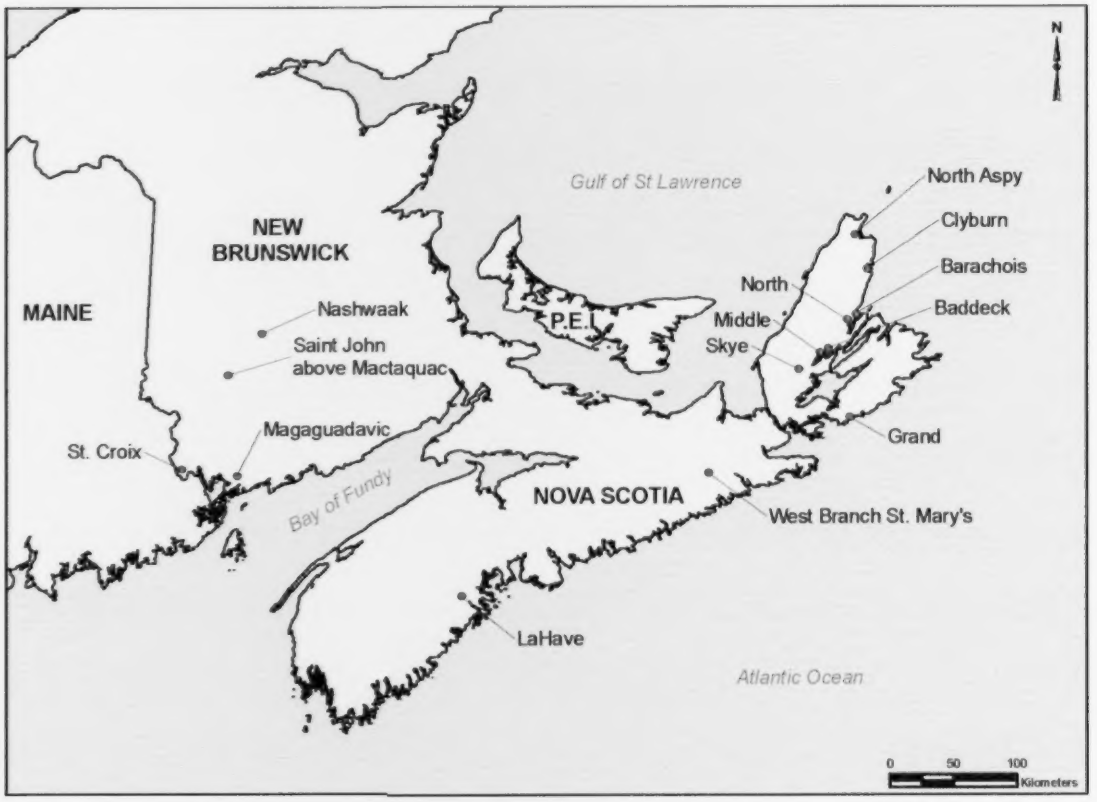
O'Neil, S.F., C.J. Harvie, D.A. Longard, and P.G. Amiro. 1998. Stock status of Atlantic salmon (*Salmo salar* L.) on the Eastern Shore of Nova Scotia, Salmon Fishing Area 20, in 1997. DFO Can. Stock Assess. Sec. Res. Doc. 1998/37.

Thorstad, E.B., T.F. Næsje, P. Fiske, and B. Finstad. 2003. Effects of hook and release on Atlantic salmon in the River Alta, northern Norway. Fish. Res. 60: 293–307.

Tufts B.L., K. Davidson, and A.T. Bielak. 2000. Biological implications of 'catch and release' angling of Atlantic salmon; pp. 195-224. In: F.G. Whoriskey, Jr. and K.E. Whelan (eds.) Managing Wild Atlantic Salmon: New challenges-New Techniques. Proceedings of the 5th International Atlantic Salmon Symposium. The Atlantic Salmon Trust & The Atlantic Salmon Federation. Saint John, New Brunswick: Quebecor Printing Atlantic.

Appendices

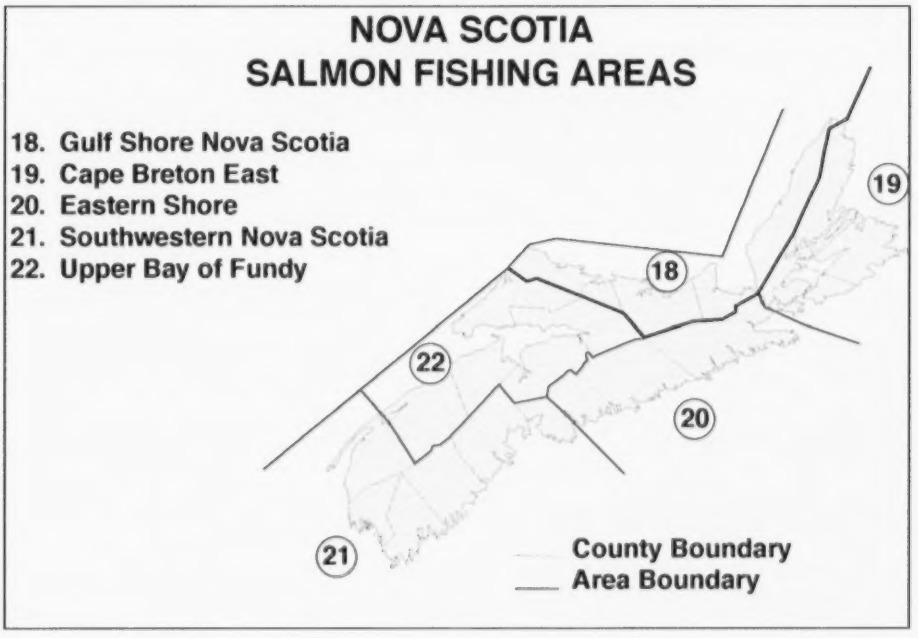
Appendix 1. Map showing the locations of Atlantic salmon rivers mentioned in this response.



Appendix 2: Fisheries and Oceans Canada Notice: 2011 Salmon Angling Seasons for Nova Scotia.

2011 SALMON ANGLING SEASONS

The Regional Director-General, Maritimes Region, Department of Fisheries and Oceans wishes to advise the public of the following changes to seasons and bag limits for Atlantic salmon in Nova Scotia.



1. (a)	**SALMON FISHING AREA 18 (Gulf Shore of Nova Scotia)** and all waters of the Province flowing into that Area, except the waters referred to in paragraphs **(b)** to **(j)**	Sept. 1 to Oct. 31
(b)	East River, Pictou County	Sept. 1 to Oct. 31
(c)	West River, Pictou County	Sept. 1 to Oct. 31
(d)	River Phillip	Sept. 1 to Oct. 31
(e)	Wallace River	Sept. 1 to Oct. 31
(f)	West River, Antigonish County	Sept. 1 to Oct. 31
(g)	South River, Antigonish County	Sept. 1 to Oct. 31
(h)	Margaree River, Northeast Margaree River, Southwest Margaree River and tributaries, except the waters referred to in paragraphs (i) and (j)	June 1 to Oct. 15
(i)	Margaree River upstream from the highway bridges at East Margaree to the Big Intervale bridges on the Northeast Margaree River and upstream to the Scotsville highway bridge on the Southwest Margaree River, not including tributaries	June 1 to Oct. 31
(j)	Northeast Margaree River and tributaries upstream from the Big Intervale Bridges	**Closed all year**

NOTES FOR SALMON FISHING AREA 18

- **THE DAILY CATCH AND RETAIN LIMIT IS TWO GRILSE (SALMON LESS THAN 63 CM IN LENGTH).**
- **THE DAILY CATCH AND RELEASE LIMIT IS ANY COMBINATION OF GRILSE OR SALMON TOTALING FOUR.**

- THE YEARLY CATCH AND RETAIN LIMIT IS FOUR GRILSE (SALMON LESS THAN 63 CM IN LENGTH).
- WHEN FISHING FOR SALMON, ONLY BARBLESS OR PINCHED BARB ARTIFICIAL FLIES ARE PERMITTED FROM OCTOBER 1 TO OCTOBER 31, INCLUSIVE.

2. (a) **SALMON FISHING AREA 19 (Cape Breton East)** and all waters of the Province flowing into that Area, except the waters referred to in paragraphs **(b)** to **(f)** ..... **Closed all year**
   (b) Baddeck River ..... (catch and release only) Oct. 1 to Oct. 31
   (c) Middle River ..... (catch and release only) Oct. 1 to Oct. 31
   (d) North River downstream from the area known as "The Benches" as marked by a Fishery Officer ..... (catch and release only) June 1 to Oct. 31
   (e) North River upstream from the area known as "The Benches" ..... **Closed all year**
   (f) North Aspy River ..... (catch and release only) June 1 to July 15 ..... and Sept. 1 to Oct. 31

NOTES FOR SALMON FISHING AREA 19

- THE ANGLING SEASONS IN ITEMS (b), (c), (d) and (f) ARE OPEN TO CATCH AND RELEASE FISHING ONLY ON THE ABOVE SPECIFIED DATES AND ARE SUBJECT TO IN-SEASON ADJUSTMENTS.
- THE DAILY CATCH AND RELEASE LIMIT IS ANY COMBINATION OF GRILSE OR SALMON TOTALING TWO.
- WHEN FISHING FOR SALMON, ONLY BARBLESS OR PINCHED BARB ARTIFICIAL FLIES ARE PERMITTED.

3. **SALMON FISHING AREA 20 (Eastern Shore)** and all waters of the Province flowing into that Area ..... **Closed all year**

4. **SALMON FISHING AREA 21 (Southwestern Nova Scotia)** and all waters of the Province flowing into that Area ..... **Closed all year**

5. **SALMON FISHING AREA 22 (Upper Bay of Fundy)** and all waters of the Province flowing into that Area ..... **Closed all year**

REMINDERS

FOR 2011 ANGLERS ARE REMINDED THAT

- FOR THOSE RIVERS ON WHICH RETENTION IS PERMITTED, THE YEARLY BAG LIMIT FOR ATLANTIC SALMON IS (4) GRILSE THAT MEASURE LESS THAN 63 CM FROM THE TIP OF THE NOSE TO THE FORK OF THE TAIL.
- SALMON FISHING IS ONLY PERMITTED USING ARTIFICIAL FLIES AND, IN CERTAIN LOCATIONS AT CERTAIN TIMES, ONLY WITH BARBLESS OR PINCHED BARB HOOKS.
- ALL SALMON 63 CM OR LONGER MUST BE RETURNED TO THE WATER IN A MANNER THAT CAUSES THE LEAST POSSIBLE HARM TO THAT FISH.

SEASONS AND BAG LIMITS MAY CHANGE AT ANY TIME FOR CONSERVATION REASONS AND SUBJECT TO ABORIGINAL HARVEST AGREEMENTS.

FOR FURTHER INFORMATION CONTACT THE LOCAL FISHERY OFFICER AND REFER TO MARITIMES REGION VARIATION ORDERS 2011-060, 2011-062 AND 2011-063.

FAITH G. SCATTOLON
REGIONAL DIRECTOR-GENERAL FOR THE
MARITIMES REGION

Appendix 3. Fisheries and Oceans Canada Orders varying the close times for angling for salmon (2011-060), varying the close tmes for angling for any species my certain methods (20011-062) and varying the fishing quota for fishing for salmon in the province of Nova Scotia (2011-063).

ORDER VARYING THE CLOSE TIMES FOR ANGLING
FOR SALMON IN NOVA SCOTIA

Short Title

1. This Order may be cited as the Maritimes Region Close Time Variation Order 2011-060.

Variation

2. The close times as fixed by section 61 of the ***Maritime Provinces Fishery Regulations*** for waters or portions of waters set out in items 70, 73, 88 to 107, and 108 to 193 of Schedule VII thereto are hereby varied so that no person shall angle for salmon in the waters of a river set out in the Schedule to this Order during the close time set out in the Schedule for that river.

Schedule

Item	Column I Waters	Column II Close Time
	Salmon Fishing Area 18	
70.	Margaree River, downstream from the highway bridges at East Margaree, and all tributaries to the Margaree River and the Northeast Margaree River downstream from the bridges at Big Intervale.	Oct. 16 to May 31
73.	Northeast Margaree River, downstream from the bridges at Big Intervale to Cranton Bridge.	Nov. 1 to May 31
	Salmon Fishing Area 19	
88.	Salmon Fishing Area 19, including those waters set out in items 89, 91 to 100, 102, and 105 to 107, but not including items 90, 97, 101, 103 and 104.	Jan. 1 to Dec. 31
90.	Baddeck River.	Nov. 1 to Sept. 30
97.	Indian Brook, Eskasoni.	Jan. 1 to Dec. 31
101.	Middle River.	Nov. 1 to Sept. 30

Item	Column I Waters	Column II Close Time
103.	North River, Victoria County downstream from "The Benches" and;	Nov. 1 to May 31
	North River, Victoria County upstream from "The Benches".	Jan. 1 to Dec. 31
104.	North Aspy River.	July 16 to Aug. 31 and Nov. 1 to May 31.
	Salmon Fishing Area 20	
108.	Salmon Fishing Area 20 including those waters set out in items 108 to 139.	Jan. 1 to Dec. 31
	Salmon Fishing Area 21	
140.	Salmon Fishing Area 21, including those waters set out in items 141 to 164.	Jan. 1 to Dec. 31
	Salmon Fishing Area 22	
165.	Salmon Fishing Area 22, including those waters set out in items 166 to 193.	Jan. 1 to Dec. 31

Coming Into Force

3. This Order shall come into force on June 1, 2011 and remain in force until December 31, 2011, unless otherwise revoked, at which time the close times shall revert to that set out in said Regulations.

ORDER VARYING THE CLOSE TIME FOR
ANGLING, FOR ANY SPECIES OF FISH BY CERTAIN METHODS,
IN CERTAIN WATERS OF THE PROVINCE OF NOVA SCOTIA

Short Title

1. This Order may be cited as the Maritimes Region Close Time Variation Order 2011-062.

Variation

2. The close time as fixed by subsection 16(1) of the *Maritimes Provinces Fishery Regulations* and set out in item 2 of Schedule IV, there to is hereby varied so that no person shall angle for salmon in the waters set out in column I, by a method set out in Column II, during the close time set out in Column III of Schedule IV of this Order.

Schedule

Item	Column I Waters	Column II Method	Column III Close Time
1.	All Salmon Fishing Area 18 as described in the *Maritimes provinces fishery regulations*.	(1) Artificial fly (2) Unbaited lure (3) Bait (4) Barbed hook (5) Barbless hook (6) Single barbless hook (7) Any other method except the method mentioned below: Artificial fly with barbless hook only.	Nov. 1 to May 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Nov. 1 to Sept. 30
	All Salmon Fishing Area 19 as described in the *Maritimes provinces fishery regulations*.	(1) Artificial fly (2) Unbaited lure (3) Bait (4) Barbed hook (5) Barbless hook (6) Single barbless hook (7) Any other method except the method mentioned below: Artificial fly with barbless hook only.	Nov. 1 to May 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Nov. 1 to May 31
	All Salmon Fishing Area 20 as described in the *Maritimes provinces fishery regulations*.	(1) Artificial fly (2) Unbaited lure (3) Bait (4) Barbed hook (5) Barbless hook (6) Single barbless hook (7) Any other method except the method mentioned below: Artificial fly with barbless hook only.	Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31
	All Salmon Fishing Area 21 as described in the *Maritimes provinces fishery regulations*.	(1) Artificial fly (2) Unbaited lure (3) Bait (4) Barbed hook (5) Barbless hook (6) Single barbless hook (7) Any other method except the method mentioned below: Artificial fly with barbless hook only.	Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31
	All Salmon Fishing Area 22 as described in the *Maritimes provinces fishery regulations*.	(1) Artificial fly (2) Unbaited lure (3) Bait (4) Barbed hook (5) Barbless hook (6) Single barbless hook (7) Any other method except the method mentioned below: Artificial fly with barbless hook only.	Jan. 1 to Dec 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31 Jan. 1 to Dec. 31

Coming Into Force

3. This Order shall come into force on June 1, 2011 and remain in force until December 31, 2011, unless otherwise revoked, at which time the close times shall revert to that set out in said Regulations.

ORDER VARYING THE FISHING QUOTA FOR FISHING FOR SALMON IN THE PROVINCE OF NOVA SCOTIA

Short Title

1. This Order may be cited as the Maritimes Region Quota Variation Order, 2011-063.

Variation

2. The daily catch and retain quotas as fixed by paragraph 62(a) of the ***Maritime Provinces Fishery Regulations*** and set out in column III of items 88 to 107 of Schedule VII to the said Regulations for salmon fishing in Salmon Fishing Area 19 are hereby varied to be 0.

3. The daily Catch and retain quotas as fixed by paragraph 62(a) of the ***Maritime Provinces Fishery Regulations*** and set out in column III of items, 109 to 139 of Schedule VII to the said Regulations for salmon fishing in Salmon Fishing Area 20 is hereby varied to be 0.

4. The daily catch and release quota as fixed by paragraph 64(b) of the ***Maritime Provinces Fishery Regulations*** and set out in column IV of items 89 to 100, 102 and 105 to107 of Schedule VII to the said Regulations for salmon fishing in Salmon Fishing Area 19 are hereby varied to be 0.

5. The daily catch and release quota as fixed by paragraph 64(b) of the ***Maritime Provinces Fishery Regulations*** and set out in column IV of items 90, 101, 103 and 104 of Schedule VII to the said Regulations for salmon fishing in Salmon Fishing Area 19 are hereby varied to be 2.

6. The daily catch and release quota as fixed by paragraph 64(b) of the ***Maritime Provinces Fishery Regulations*** and set out in column IV of items, 125, 130, and 135 of Schedule VII to the said Regulations for salmon fishing in Salmon Fishing Area 20 are hereby varied to be 0.

7. The daily catch and release quota as fixed by paragraph 64(b) of the ***Maritime Provinces Fishery Regulations*** and set out in column IV of items, 148, 150, 156, 158, 162, and 164 of Schedule VII to the said Regulations for salmon fishing in Salmon Fishing Area 21 are hereby varied to be 0.

8. The yearly fishing quotas as fixed by paragraph 62(b) of the ***Maritime Provinces Fishery Regulations*** and set out in column V of items 88 to 164 of Schedule VII to the said Regulations for salmon fishing in Salmon Fishing Area 19, 20, and 21 are hereby varied so that no person shall catch and retain more than 0 salmon of which not more than 0 may be 63 cm in length or longer.

9. The yearly fishing quotas as fixed by paragraph 62(b) of the ***Maritime Provinces Fishery Regulations*** and set out in column V of items 65, 70, 73, 77, 79, 80, 81, 84, 86 and 87 of

Schedule VII to the said Regulations for salmon fishing in Salmon Fishing Area 18 is hereby varied so that no person shall catch and retain more than 4 salmon of which not more than 0 may be 63 cm in length or longer.

10. The yearly fishing quota as fixed by paragraph 63(b) of the ***Maritime Provinces Fishery Regulations*** and set out in column IV of item 1 of the table to that section is hereby varied so that no person shall catch and retain more salmon in any year than 4 of which only 0 may be 63 cm in length or longer.

Coming Into Force

11. This Order shall come into force on June 1, 2011 and remain in force until December 31, 2011, unless otherwise revoked, at which time the close time shall revert to that set out in said regulations.

Appendix 4. Reported recreational catch in SFAs 19 for 2011 (preliminary: February 2, 2012, database query), 2010, and the average catches for 2006-2011 time period. All salmon fisheries in SFA 20 to 23 were closed during this time period.

	2011 (Preliminary)				2010				5 Year Mean (2006-2010)							
	Grilse		Salmon	Effort	Grilse		Salmon	Effort		Grilse			Salmon		Mean Effort	
	Retained	Released	Released	Rod-days	Retained	Released	Released	Rod-days	Retained	95% CI	Released	95% CI	Released	95% CI	Rod-days	95% CI
SFA 19: EASTERN CAPE BRETON ISLAND																
ACONI BROOK	River Closed				River Closed				0	0	0	0	0	0	0	0
BADDECK	3	135	317	711	0	58	159	383	0.3	0.9	27.1	22.9	98.2	59.6	344.1	115.9
BARACHOIS	0	6	0	22	River Closed				0	0	2.3	5.3	1.4	1.8	10.3	17.7
CATALONE	River Closed				0	0	2	14	0	0	0	0	0.5	1.3	2.8	7.8
CLYBURNE	River Closed				River Closed				0	0	0	0	0	0	0	0
FRAMBOISE (GIANT LAKE	River Closed				River Closed				0	0	0.8	2.4	0.3	0.8	6.3	11.6
FRENCHVALE BROOK	River Closed				River Closed				0	0	0	0	0	0	0	0
GASPEREAUX: C. BRETON CO.	River Closed				River Closed				0	0	0	0	0.4	1.2	1.2	3.8
GERRATT	River Closed				River Closed				0	0	0	0	0	0	0	0
GRAND	River Closed				River Closed				0	0	7.7	8.5	1.2	2.2	30.3	4.9
GRANT MIRE BROOK	0	0	0	9	River Closed				0	0	1.5	4.9	2	2.2	10.2	9.7
INDIAN BROOK	0	0	3	22	0	0	0	2	0	0	1.2	3.8	0	0	9.2	12.8
INGONISH	0	0	0	3	River Closed				0	0	0	0	0	0	1.2	3.8
INHABITANTS	River Closed				River Closed				0	0	3.8	5.1	8.6	13.9	20.6	33
LITTLE LORRAINE	River Closed				River Closed				0	0	0	0	0	0	0	0
LORRAINE BROOK	River Closed				River Closed				0	0	0	0	0	0	0	0
MACASKILL'S BROOK	River Closed				River Closed				0	0	0	0	0	0	0	0
MARIE JOSEPH	River Closed				River Closed				0	0	0	0	0	0	1.4	1.6
MIDDLE: VICTORIA CO.	3	169	179	646	0	72	217	736	0	0	42.4	28.3	126.4	83.5	559.1	187.6
MIRA	River Closed				River Closed				0	0	0	0	0	0	2.4	7.6
NORTH ASPY	0	3	15	43	0	12	14	70	0	0	6	9.5	8.1	7.6	37.5	44.9
NORTH: VICTORIA CO.	0	203	489	825	0	150	292	629	0	0	97	49.1	176	89	558.3	115.4
NORTHWEST BROOK (RIVER RYAN)	River Closed				River Closed				0	0	0	0	0	0	0	0
RIVER BENNETT	River Closed				River Closed				0	0	0	0	0	0	0	0
RIVER DENY'S	River Closed				River Closed				0	0	0.4	1.2	0	0	1.1	3.6
RIVER TILLARD	River Closed				River Closed				0	0	0.8	2.5	0.4	1.3	1.6	5
SAINT ESPRIT	River Closed				River Closed				0	0	0	0	0	0	0	0
SALMON: CAPE BRETON CO.	River Closed				River Closed				0	0	0.6	1.2	0.4	1.1	9.1	10.9
SKYE	River Closed				River Closed				0	0	0	0	0	0	0	0
SYDNEY	River Closed				River Closed				0	0	0	0	0	0	0	0
SFA TOTALS:	6	517	1003	2281	0	292	685	1834	0.3	0.9	187.8	93.6	420.9	205.7	1585.6	317.6

Note: In 2011, an incentive program was offered (draw prizes) for anglers returning their completed license stubs before the end of December. This may have improved return rates.

This Report is Available from the:

Centre for Science Advice,
Maritimes Region
Department of Fisheries and Oceans
P.O. Box 1006, Stn. B203
Dartmouth, Nova Scotia
Canada B2Y 4A2

Phone number: 902-426-7070
Fax: 902-426-5435
e-mail address: XMARMRAP@mar.dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

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